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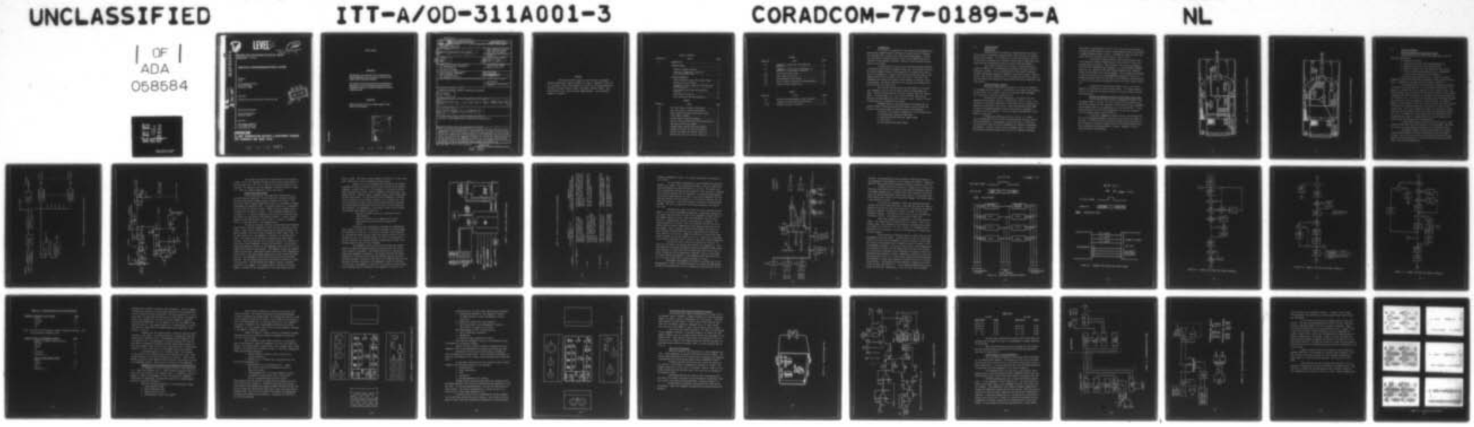

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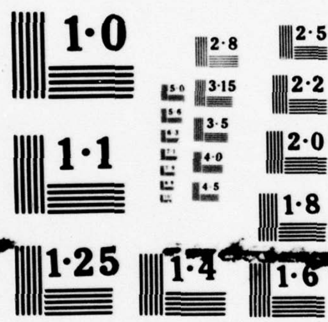
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM- 77-0189-3

VEHICULAR INTERCOMMUNICATIONS SYSTEM

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August 1978

Third Quarterly Report for Period 1 April, 1978 to 30 June, 1978

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This is the Third Quarterly Report for the design study for a vehicular intercommunication system primarily for tracked vehicles. The report covers the time period from 1 April 1978 through 30 June 1978. Accomplishments for this period include the considerations for installation of the intercom in the M-60 and XM-1 tanks. This involves the suggested techniques for cabling and reducing the number of connectors on the commander's control box. During this period the TDM breadboard was tested for operatability in a noise environment. The microprocessor control system is explained and flow diagrams are presented.

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FOREWARD

This Third Quarterly Report on the Vehicular Intercommunications System Study, Contract DAAB07-77-C-0189, is submitted 3 July 1978 for the period 1 April 1978 through 30 June 1978 by ITT Aerospace/Optical Division, 3700 East Pontiac Street, Fort Wayne, Indiana 46803. Technical Monitor is Mr. Glenn Williman, DRDCO-COM-RN-3. ITT-A/OD Report Number is 311A001-3.

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1.0 INTRODUCTION

In the first two quarters of the Vehicular Intercommunication System Study, tradeoff analyses were done in several areas to determine the techniques best suited to fill the intercom requirements. Activity for this quarter included extensive review of the tradeoff data which resulted in the technique selection. Results of these reviews are presented in this report.

To substantiate the selection of the TDM signaling technique, a breadboard which modeled a command station and a crew station was built. With this breadboard, there is the capability of a duplex voice link as well as the capability to control from the crew station the input at the command station that is routed to the crew station. Testing of this breadboard has started this quarter and the results of testing to date are presented. The Harris CVSD device was received and tested and compared with Motorola CVSD circuit.

The ITT-A/OD Intercom System has been defined to the place that commander's station size and cable connection requirements are known. Installation problems for the major Intercom users were investigated. A trip was made to Ft. Knox to see the M-60A1 tank and the Chrysler Sterling Defense plant to see the XM-1 tank. Results of these investigations are included in this report.

CORADCOM Vehicular Intercommunications System Project engineers, Messrs. Glenn Williman and Steve Waldman visited ITT-A/OD for review of the study program and demonstration of the breadboard.

This report also contains information in the following areas:

- Microprocessor design and algorithms
- Power distribution and power supply design
- LSA activity
- Crew station front panel design

2.0 INTERCOM SYSTEM

Study Review

During the first two quarters, tradeoff analysis was done in several areas to determine techniques which would best fill the requirements of the intercom. In the early part of the third quarter, the work of the first two quarters was reviewed to assure that all applicable techniques had been considered and that the analysis had been complete.

The wireless analysis did not yield a technique which was capable of meeting all the operational requirements for both inside and outside the vehicle. This is caused mainly by the external intercept distance requirements originally imposed on the wireless system. Because of this, the wireless techniques will be reviewed and analyzed for use inside the vehicle only during the fourth quarter and will be reported in the final report.

Logistics Support Analysis

The initial LSAM report dated March 31, 1978, was submitted in accordance with the contract. MIL-M-38510, Class B parts were utilized for the initial run in order to meet the 12,000 hour MTBF requirement. This resulted in a high unit production cost.

Following the initial LSAM report, the material list was changed from MIL-M-38510, Class B, to MIL-M-38510, Class C, parts. This resulted in a 65K dollar reduction in life-cycle-cost and a reduction in operational availability from .9755 to .9224 (when permitting the GEMM to select the optimum maintenance policy from policies 3 through 5, 7 through 15, and 17 through 31). This also reduced the MTBF from 17,000 hours to 3,000 hours.

Following the GEMM run with Class C parts, W. R. Sloan visited CERCOM (May 10 and 11, 1978) and discussed the two runs with Mr. Bruce Ballance and Mr. Irving Soutag. After this visit, a copy of the run with Class C parts was sent to CERCOM for Mr. Balance's information and comments. Since Mr. Sloan's visit to CERCOM, Notice 2 to MIL-STD-217B has been obtained and the Class C parts list updated accordingly.

Additionally, the GEMM input file for Class C parts has been modified to incorporate CERCOM comments relative to maintenance policies and handling of common components and/or modules. New GEMM runs utilizing these modified inputs are scheduled for the week of June 12, 1978.

The Logistics Support Analysis status was reviewed as part of the Vehicular Intercom Program Review on May 24 and 25, 1978 at ITT Aerospace/Optical Division. Those present at this review included Mr. Glenn Williman (CORADCOM Project Engineer), Mr. Steve Waldman (CORADCOM Engineer), Mr. John Heitz (ITT-A/OD Program Manager/Project Engineer), and Mr. William Sloan (ITT-A/OD ILS Manager). Mr. Williman was requested to provide ITT-A/OD with any CORADCOM/CERCOM suggestions relative to a maximum acceptable Mean Down Time (MDT) for the Vehicular Intercom System so they can be taken into consideration during ITT-A/OD's tradeoff analysis.

The Vehicular Intercom System material list is now being updated to incorporate the latest design concept. This updated material list will be utilized for LSAM and sensitivity analysis during the week reporting period.

Location of Commander's Station on M-60 Tank and XM-1 Tank

The ITT-A/OD Intercom System is configured differently from the present AN/VIC-1 system. The "new" intercom system eliminates the AM-1780 and combines all the functions of this module into the commander's station module which is the same physical size as the AM-1780. (A complete description of the ITT-A/OD commander's station can be found in the First Quarter Report, ECOM-77-0189-1-A).

An auxiliary commander's station, which is the same physical size as the proposed commander's station, will be used by the loader in the tank. In the M-60 it can fit where the present intercom station is; and in the XM-1 it could be located either at the present station location or where the AM-1780 amplifier is located. Figures 2-1 and 2-2 show the typical system hookup.

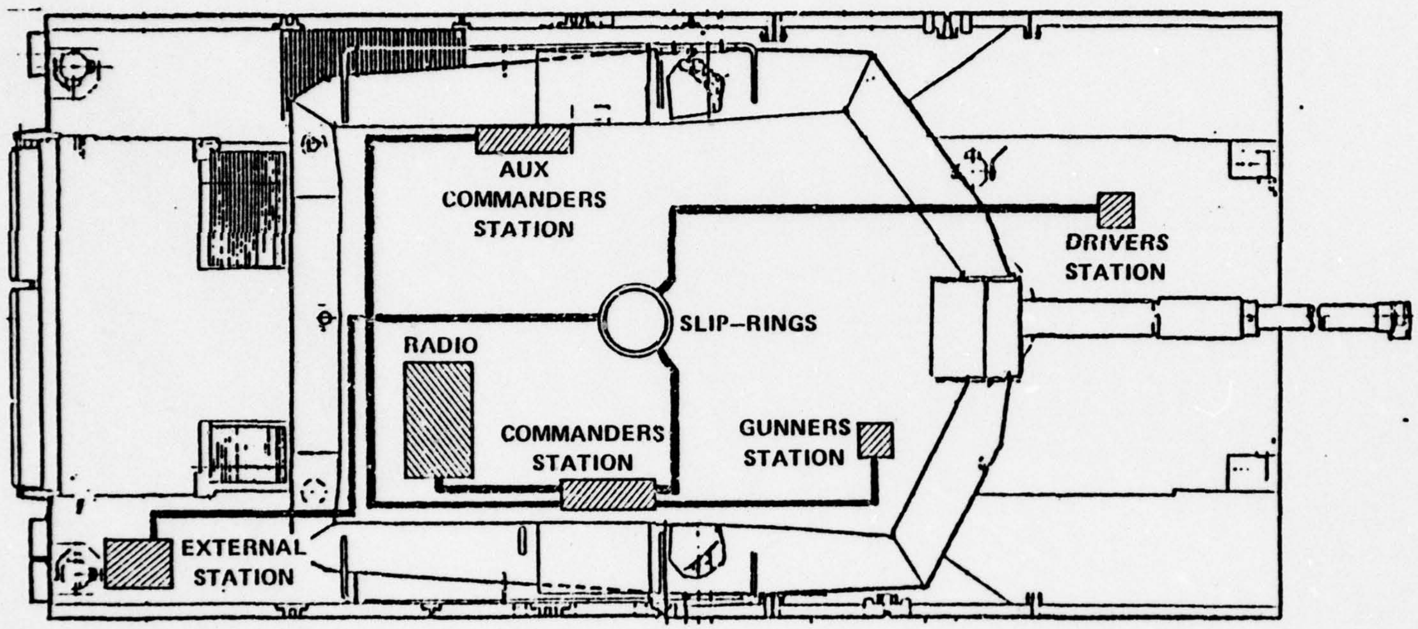


FIGURE 2-1: M-60 TANK TYPICAL INTERCOM INTERCONNECT

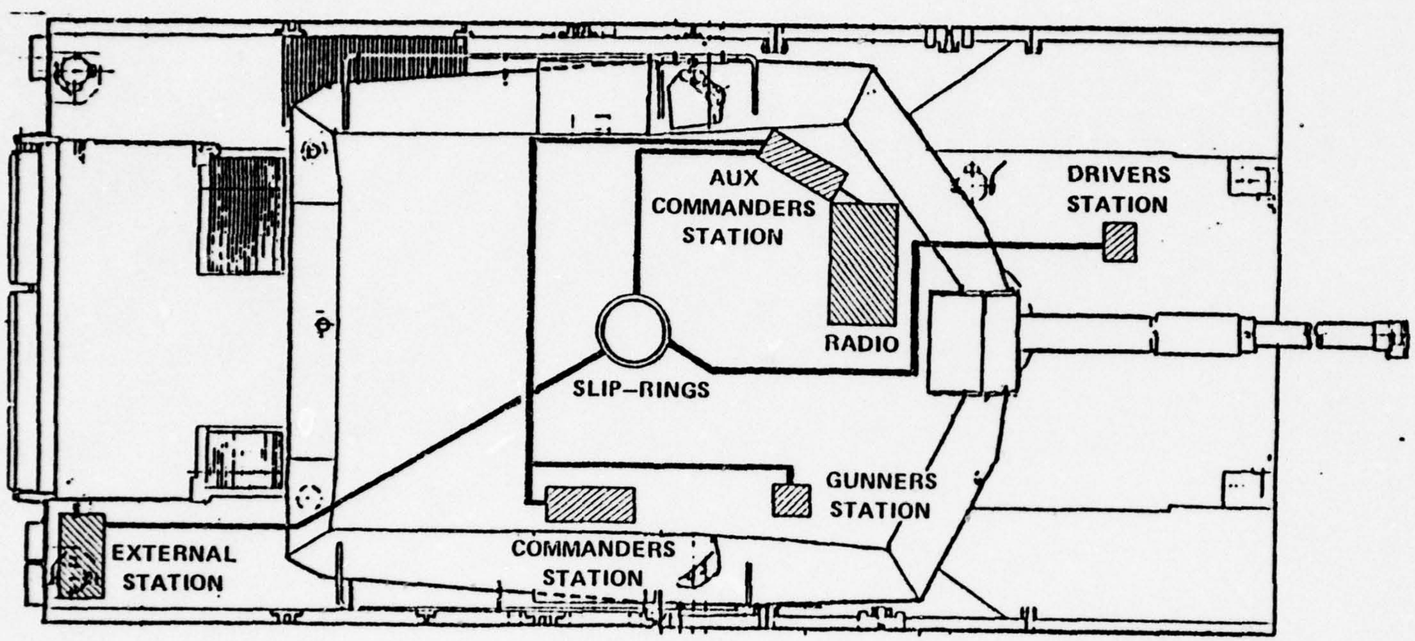


FIGURE 2-2: XM-1 TANK TYPICAL INTERCOM INTERCONNECT

3.0 INTERCOM COMPONENTS

Power Distribution and Power Supply Design

The intercom power distribution and power supply have the following requirements:

- Transient protection
- Protection of vehicle from intercom malfunction
- Regulated voltage for logic and CVSD device
- Provide dc power to all the "satellite" crew stations
- Protect intercom from malfunction due to malfunction of one or more "satellite" crew stations.

The system block diagram, Figure 3-1, depicts the major elements of the power distribution system used to meet the above requirements. Schematics of the major blocks are shown in Figure 3-2.

The transients which the intercom must withstand are defined by MIL-STD-1775 and MIL-STD-461A. Also outlined by MIL-STD-461A is the amount of ac energy that can be conducted on to the battery lines. The vehicle battery line at the input to the intercom system is routed through a transient filter which protects the vehicular intercom from transients on the battery line. This filter also prevents noise from being conducted back onto the dc lines in compliance with MIL-STD-461A. An electromagnetic circuit breaker follows the filter to protect the vehicle battery line should the intercom malfunction to the point of a short on the battery line. The circuit breaker has a built-in time delay to prevent transients from activating the circuit breaker and disabling the intercom. This is followed by a second filter which is designed for lower frequencies which aids in transient protection and also prevents conducted energy from getting onto the battery line.

A Zener diode follows this filter to protect against large transients and limits the input voltage to 40 volts maximum. The diode also serves as reverse polarity protection for the intercom system.

The battery voltage is then routed through the dc control switch and distributed to the crew station modules and the command station. The dc lines to all the crew stations are protected by foldback current limiters which will allow the intercom system to operate when a crew station malfunctions.

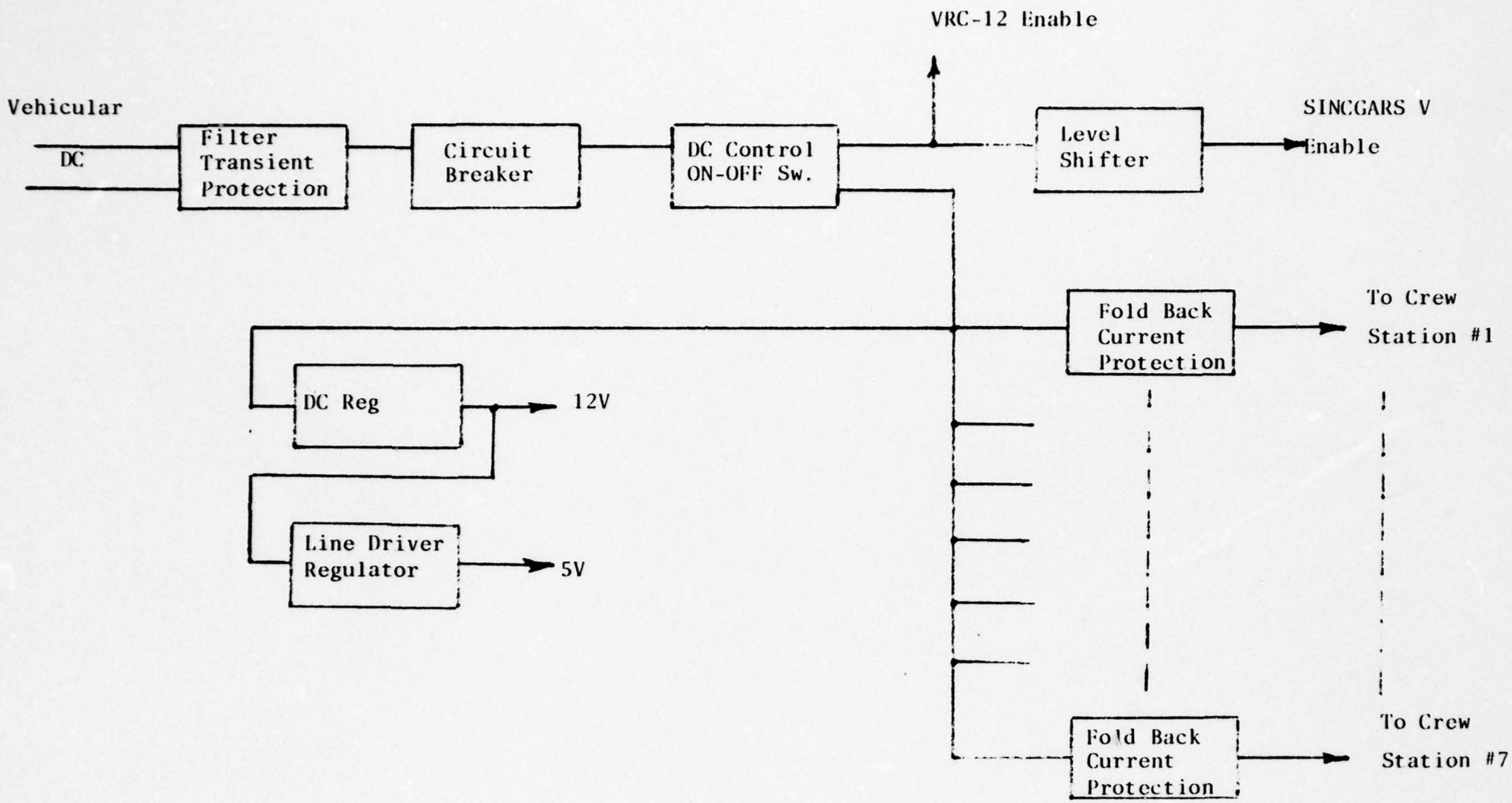


Figure 3-1: Block Diagram of Power Distribution System

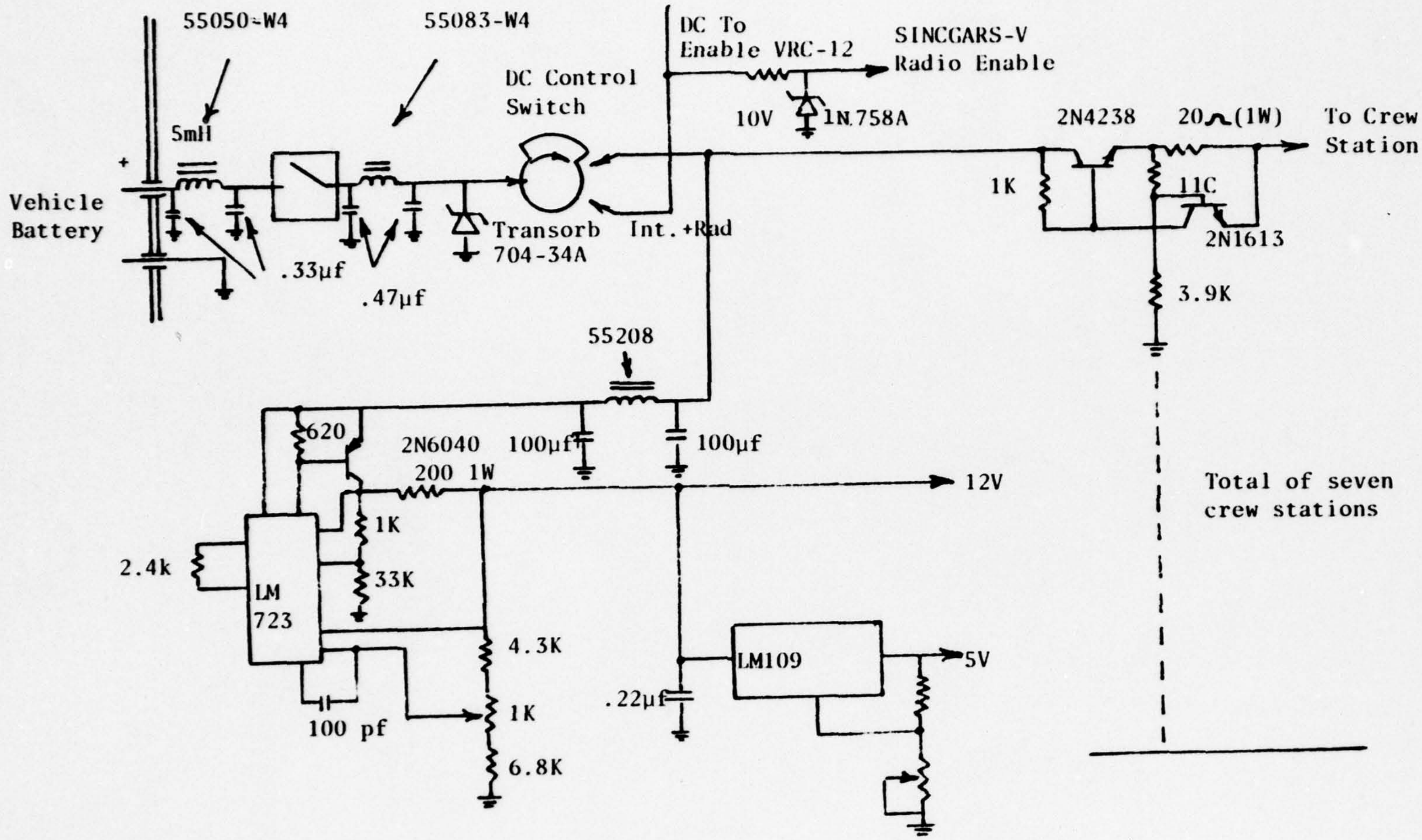


Figure 3-2: Power Supply Schematic

Two voltages are required for the operation of the intercom system. The 12 volt regulated voltage is used for the analog portions of the system and the 6 volt level is used for the digital portion of the intercom. The regulators for the commander's station are shown in Figure 3-2. There is a similar regulator in each crew station.

Central Controller Design

In the third quarter, a microprocessor based central controller design was completed. The work resulted in hardware selection and basic interconnect diagrams along with general flow charts. The flow charts detail computer program flow and give an indication of memory requirements and execution times. The central controller is responsible for the control of vehicular radios, COMSEC, auxiliary command station interface and PTT control of radios. A block diagram illustrates this in Figure 3-3. It should be emphasized that the central controller does not control the Time Division Multiplexing networks. It does, however, sample the crew TDM networks to see if there is a request to transmit and if so, route the voice to the appropriate R/T.

The central controller provides the following three functions: radio control, auxiliary commander's station control, and press-to-talk control. Radio control involves formatting the information (preset, RF power and ECCM) to be sent serially through the remote control link. If an error should occur, the commander is alerted to try and retune the radio. The central controller does the debouncing of radio control switches. The second function of the central controller is interface between the auxiliary commander's station and the radios. The auxiliary station had identical controls as the commander's station as well as full capabilities except for radio access. The commander station has complete control in this area. Radio power switches work in an "OR" configuration which results in the radios being powered up if either station has radio power on. For retransmit control, both stations must have retransmit selected. The last function provided by the central controller is press-to-talk control. The TDM networks are sampled to detect a transmit request of a crew member. If a request exists, then the crew station number is latched into the appropriate R/T voice multiplexer and the radio is keyed. The central control operates the radios on a first come, first served basis, with the commander having override.

Figure 3-3 is a block diagram which illustrates the present assessment of control functions which must be processed by the intercom commander's control station. In this diagram, it is seen that control busses distribute and collect control information from four areas: crew member stations, vehicular radios, commander control station front panel and XMIT audio module. The processing of this information is provided by the controller I/O and central controller unit of Figure 3-3. The electrical design of these control networks must provide an efficient I/O which minimizes interconnect wires and control circuits which minimize hardware. Two approaches to the design of these I/O and control circuits have been studied and these are:

1. Discrete I/O under control of a dedicated discrete logic network.
2. Discrete I/O which can be combined into an integrated control subsystem under microprocessor control.

Of the two circuit approaches considered for implementing these control I/O functions, the following advantages and disadvantages are considered in Table 3-I. The cost of a discrete system (requires at a minimum two custom LSI and a UART) far exceeds the cost of a microprocessor system. The tradeoff analysis of Table 3-I clearly points out that the lower cost and more flexible microprocessor system is the optimum method of control for the intercom.

The commander's control station and the auxiliary control station use identical hardware except for one input, which for the auxiliary station, is grounded. The software detects this, causing the change from commander to auxiliary. The station which has the radios connected to it should also have the radio present input to the microprocessor grounded. This allows the radios to be connected either to the auxiliary station in the XM-1 or the commander's station in the M-60. In both cases, the commander's station has full control of radios regardless of whether they are connected to the commander's station or the

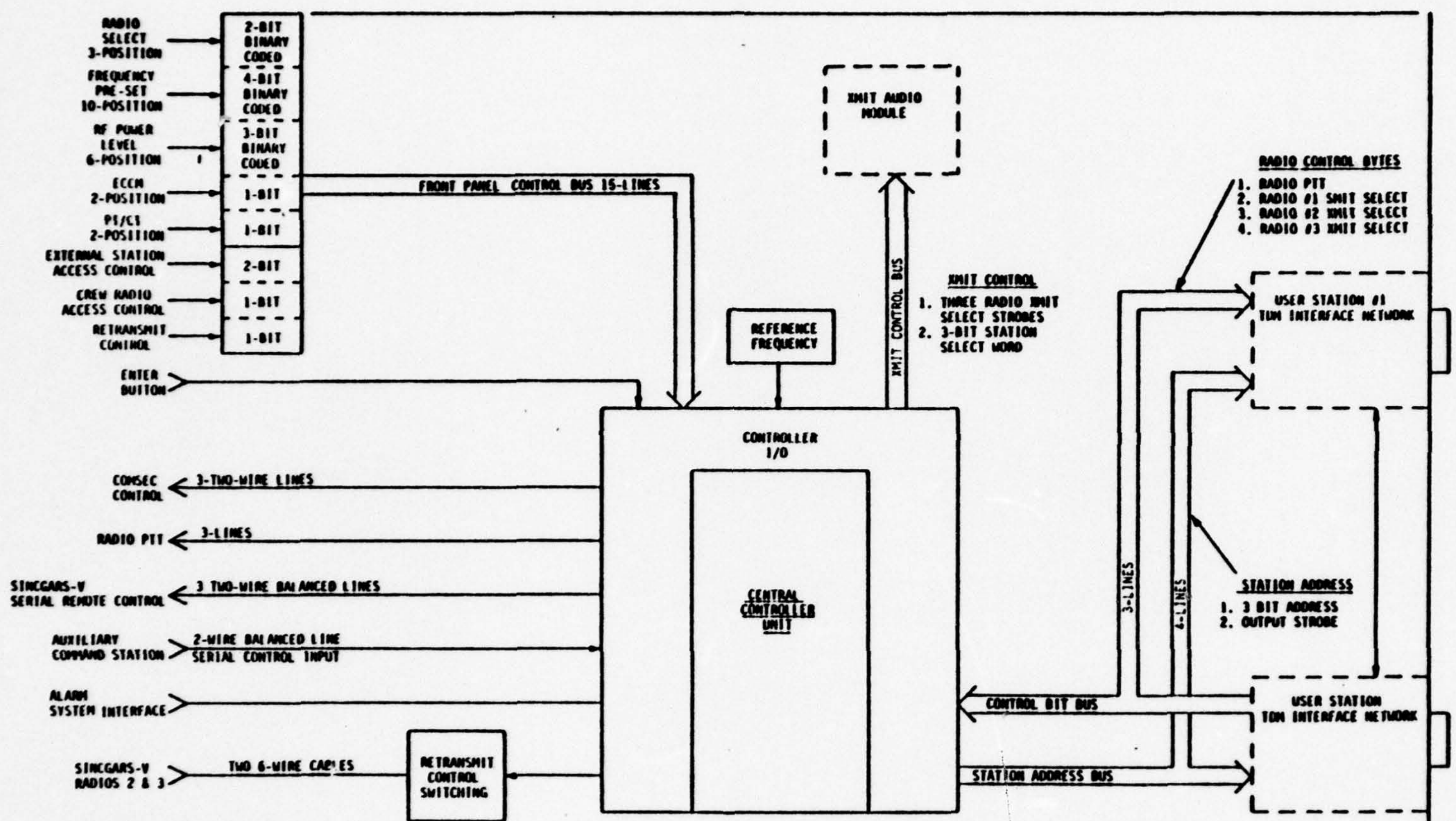


FIGURE 3-3: CONTROL SIGNAL INTERFACE DIAGRAM

Table 3-I. Discrete -vs- Microprocessor Control Approach

Criteria	Approach #1 Discrete I/O Under Discrete Logic Control	Approach #2 Discrete I/O Combined with Micro-Processor Data Bus I/O & Micro Control
1. Circuit Complexity	1. Relatively simple gate, shift register and counter configurations can provide for the design of I/O and control functions.	1. Relatively simple microprocessor configurations consisting of a processor, ROM and several I/O functions. Discrete I/O circuits are provided where necessary.
2. Size	2. Although the complexity of the discrete design approach is relatively simple, the large number of gates and shift registers results in a very large control network.	2. The use of a one-chip microprocessor results in a very small physical size for the control network.
3. Flexibility	3. Changes in intercom control functions require modification of actual circuits and are costly.	3. Changes in intercom control functions can be accomplished through simple reprogramming and are inexpensive.
4. Cost	4. A minimum of two custom LSI plus a UART is required. Development costs must also be added to this.	4. The microprocessor design is simple and straightforward using a power microprocessor.

auxiliary commander's station. The radios are physically connected to his station.

In the hardware implementation, an RCA COSMAC microprocessor, CDP1804, was chosen. This microprocessor offers a low cost, small package system because CPU, ROM and RAM are in one chip. This device will start in production during the fourth quarter of this year and is expected to be military approved shortly thereafter. If problems should develop with military qualification, the 1802 is pin-for-pin compatible with the 1804 and software could be modified so as to use only a ROM and only internal CPU registers. This would eliminate the need for read/write memory RWM. The 1802 is expected to be military qualified by the end of this year.

The 1804 has on chip 2K of ROM, 64 bytes of RAM and an 8-bit timer. It is an 8-bit SOS/CMOS microprocessor. Referring to Figure 3-4, the inputs from front panel switches of the commander's control station are sampled using tri-states to gate the information into the microprocessor. Debouncing of switches is provided for in software. R/T status information is stored in one byte of RAM for each R/T and can be output directly without reformatting to the displays using only one output command. This is possible because preset requires three bits, RF power requires three and ECCM and CT each require one bit, making the total eight bits or one byte. COMSEC is controlled by three lines which control switches to turn the COMSEC units to CT. Three bits of the same latch control R/T press-to-talk. One bit of the latch controls retransmit.

The four bit latch controls the situation of which R/T or auxiliary the digital line drivers and receivers are connected to. Software simulates a universal asynchronous receiver transmitter (UART) using the Q flip-flop in conjunction with a digital line driver and a line receiver feeding into the microprocessor using $\overline{EFI}$. One bit of the eight bit latch controls the gating of a tone generator onto the digital line so as to signal the R/T that a control message will follow.

Crew member and commander PTT control is provided for by the microprocessor. When a crew member requests to transmit, the TDM networks provide the microprocessor with this information along with which R/T was

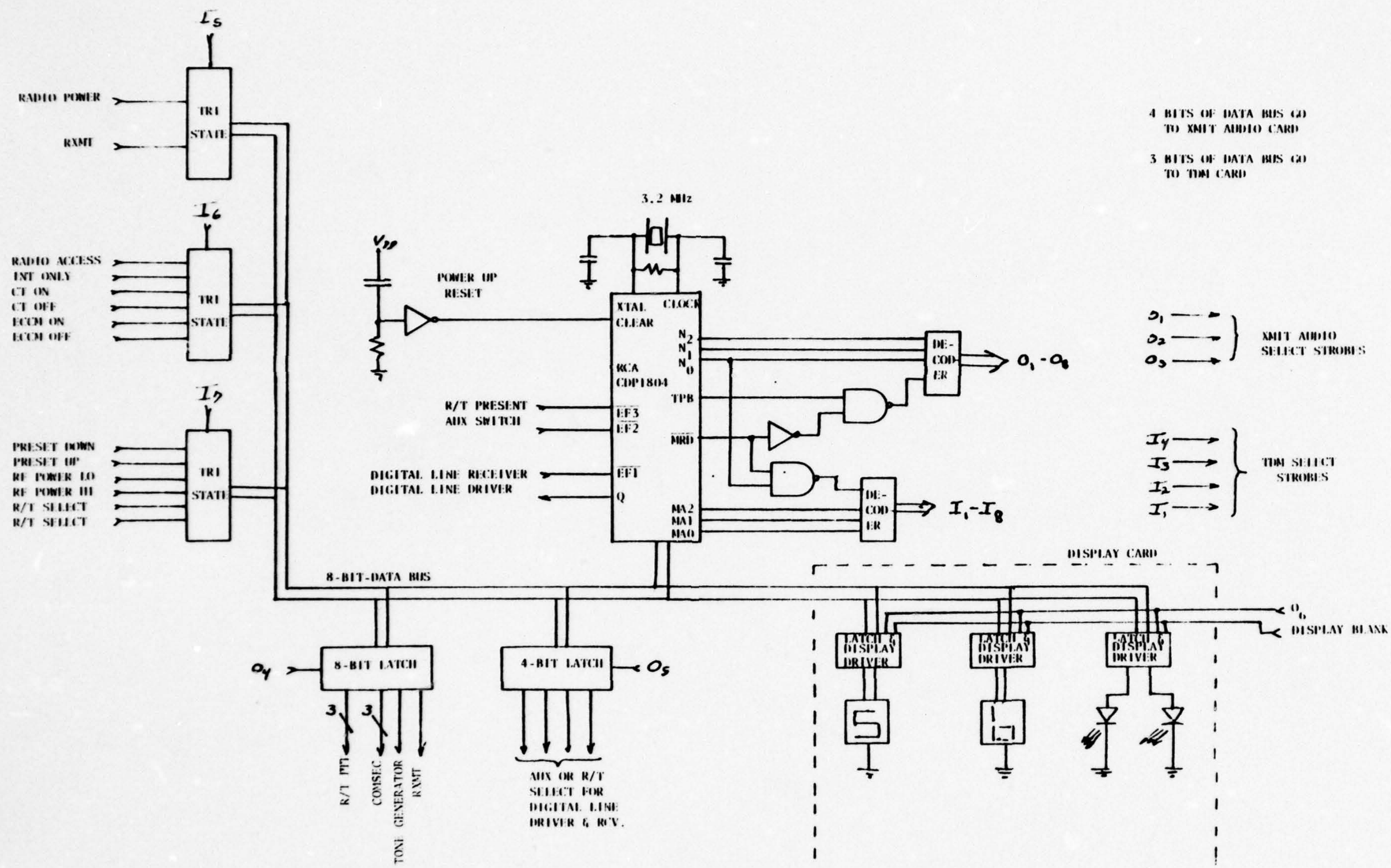


FIGURE 3-4: CENTRAL CONTROLLER USING RCA-1804 MICROPROCESSOR

selected. The microprocessor then transfers the TDM station number to the appropriate R/T multiplexer in the transmit audio module. Timing diagrams for TDM and XMIT AUDIO interfaces are shown in Figure 3-5 and 3-6.

Software flow charts are given in Figures 3-7A, 3-7B and 3-7C. These flow charts would later lead to a more detailed flowchart and then to assembly language code. A detailed flow chart should not be started until the advanced development stage (which results in deliverable hardware) because minor details of the system may change. This would require a new detailed flow chart.

For control of SINCGARS-V radios, the microprocessor must transmit and receive eight UART words. Each UART word contains eight information bits plus one start and one stop bit. The protocol of controlling a R/T remotely is explained in detail in Volume 2 of ITT-A/OD SINCGARS-V proposal. The auxiliary station will use the same UART subroutines as the R/T. Bit definitions are given in Table 3-II.

Front panel operation was explained in the second quarterly report. Two things should be repeated from this report. First, in retransmit mode, if the commander is displaying a retransmit radio status his display will flash at a 1 Hz rate. Second, if a SINCGARS-V radio should fail to tune remotely, zeros will be displayed in the preset and RF power displays.

The microprocessor software simulates a UART using the 8-bit programmable timer for timing. The UART format is used for remote operation of R/T and auxiliary commander's station interface. The R/T UART bit definition and synchronization schemes are given in Volume 2 of ITT-A/OD SINCGARS-V proposal. If an error should occur in UART transmission, the software will detect this and display zero for preset and RF power. For the auxiliary interface, the bit definitions are given in Table 3-II. Synchronization proceeds as follows: commander's station waits until the processing load is low (i.e., no R/T status change from its front panel). The commander's station then transmits the status of one R/T to the auxiliary station. The auxiliary station immediately responds with either of the two words from Table 3-II. If the command microprocessor does not detect the auxiliary transmission, a time out occurs and the command

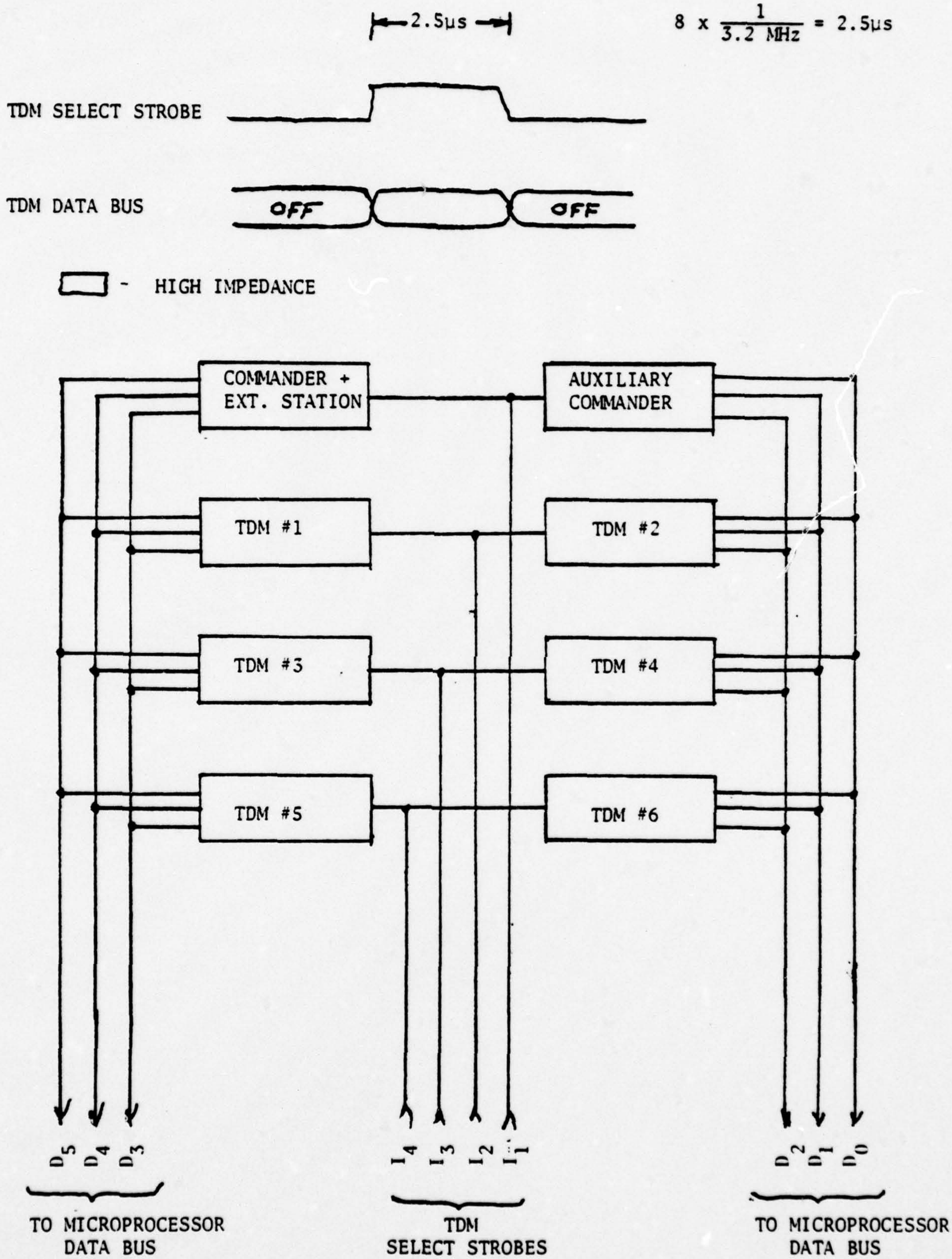
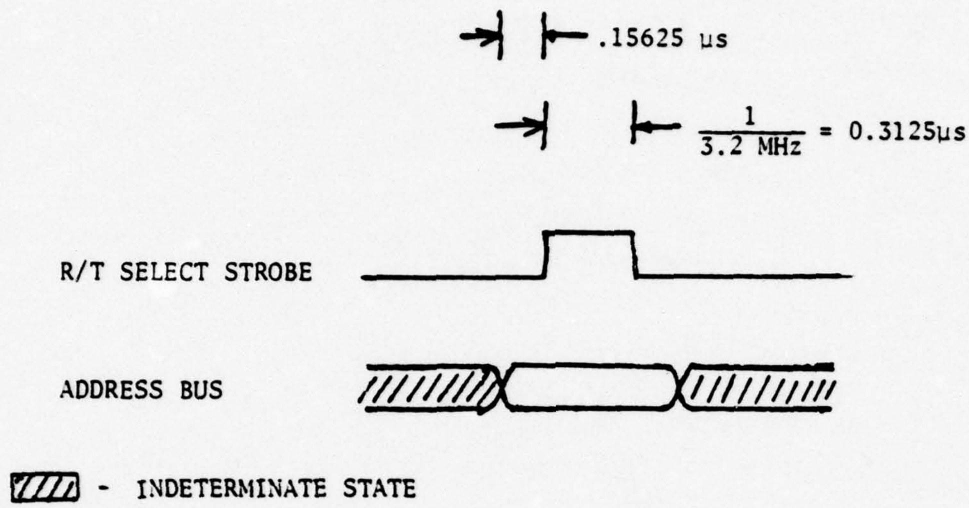


FIGURE 3-5: TDM TIMING AND WIRING DIAGRAM



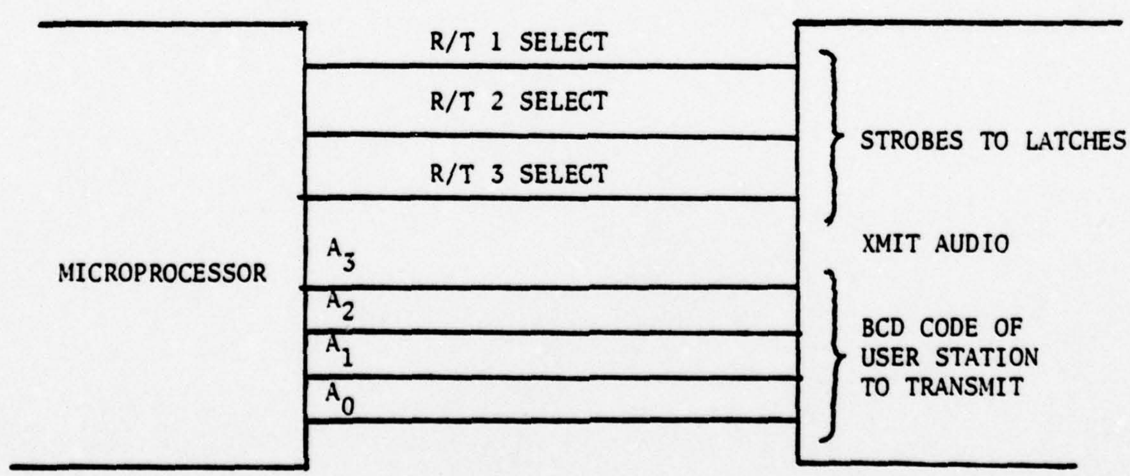


FIGURE 3-6: TRANSMIT AUDIO TIMING AND WIRING DIAGRAM

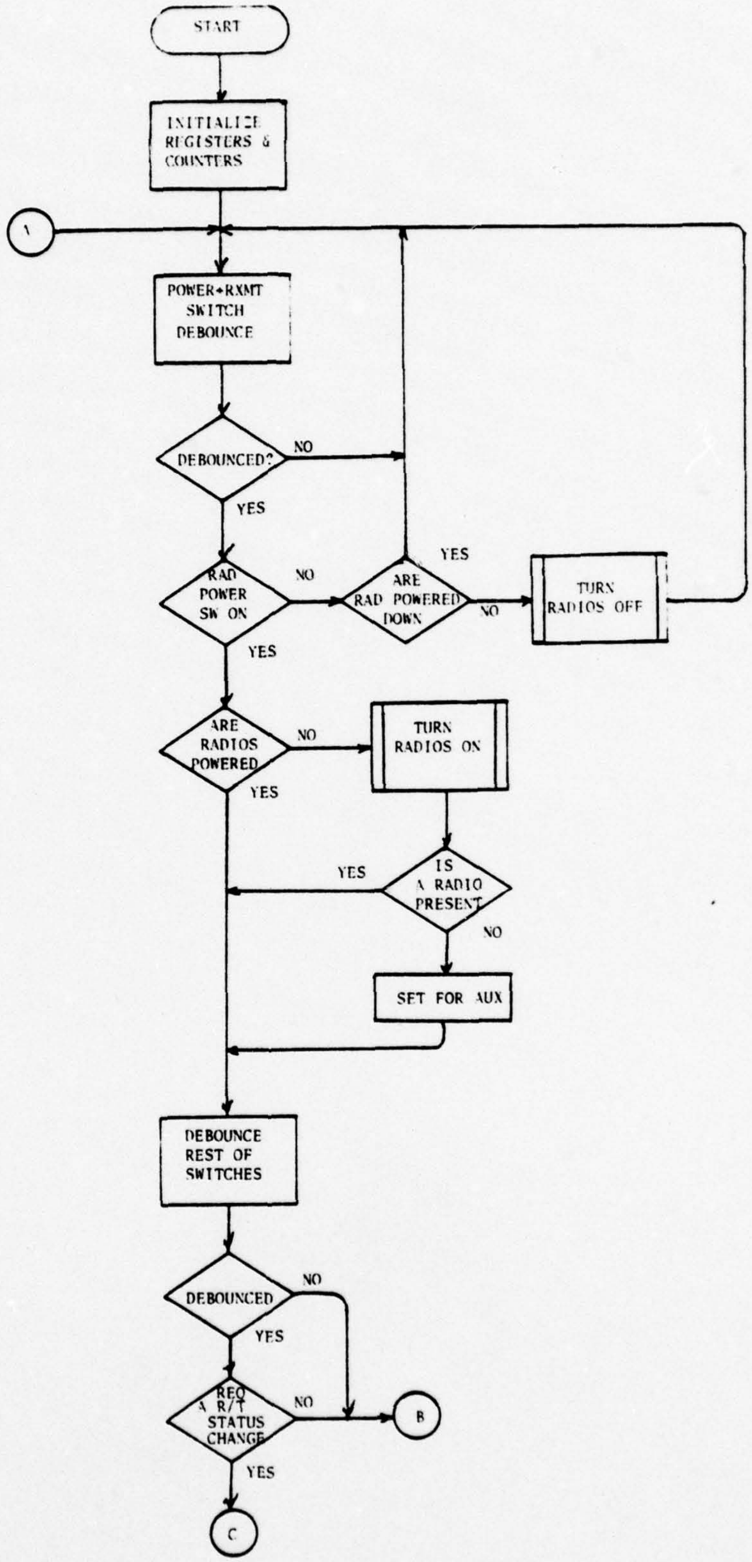


FIGURE 3-7A: GENERAL FLOW CHART FOR CENTRAL CONTROLLER

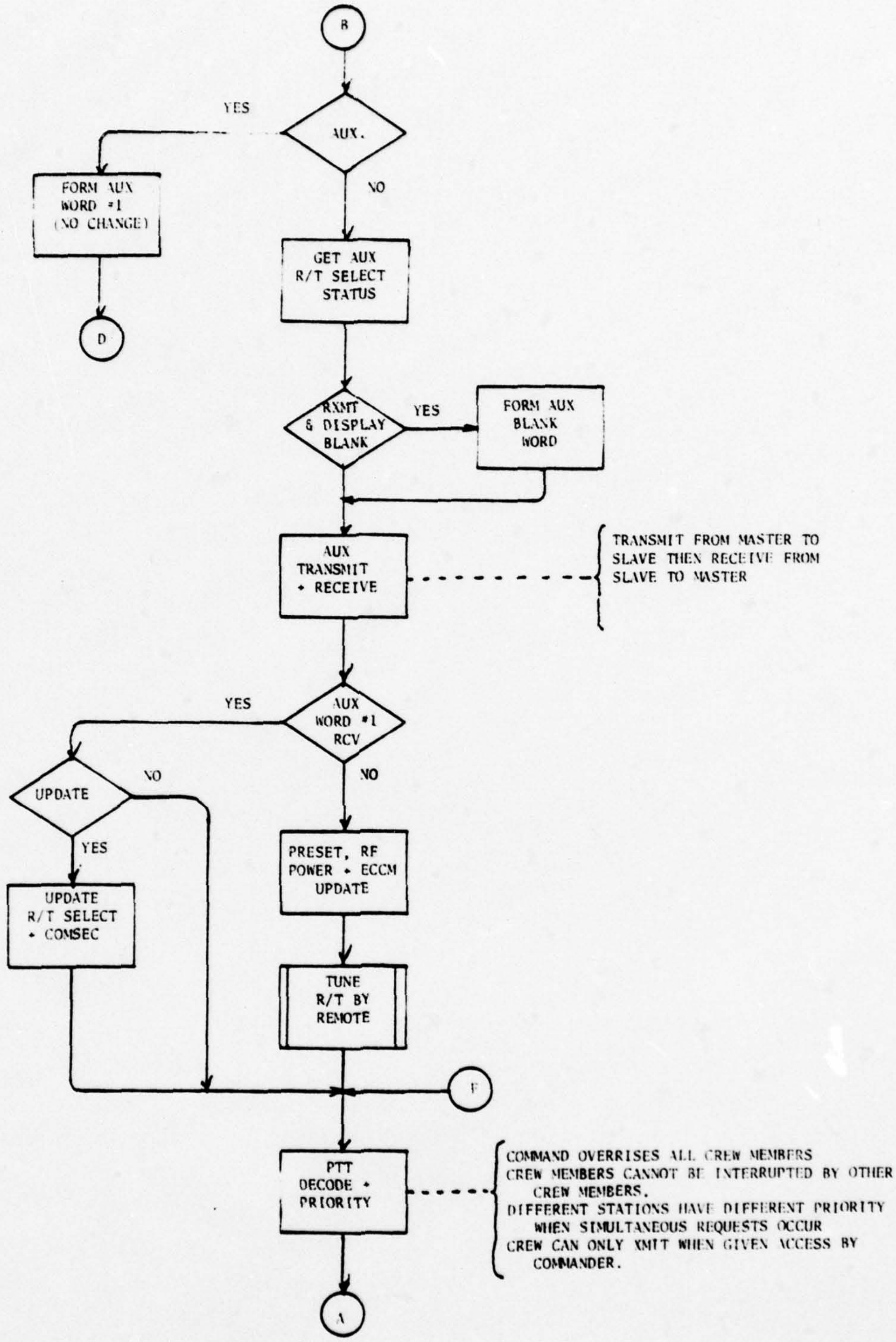


FIGURE 3-7B: GENERAL FLOW CHART FOR CENTRAL CONTROLLER

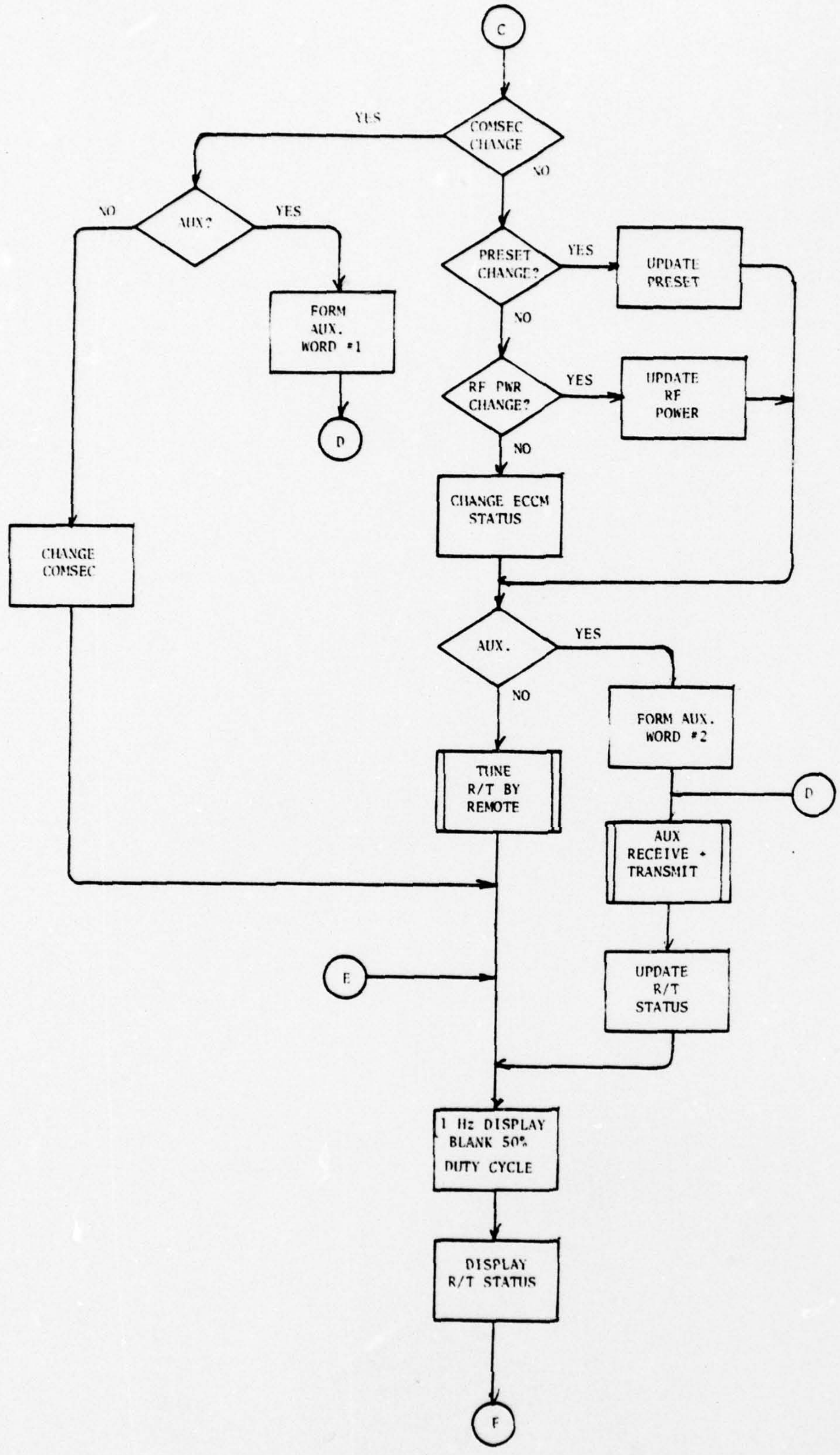


FIGURE 3-7C: GENERAL FLOW CHART FOR CENTRAL CONTROLLER

TABLE 3-II - AUXILIARY STATION UART BIT DEFINITIONS

Commander's Station to Aux. Station	BITS
Preset	5-7
RF Power	2-4
ECCM	1
CT	0

Note: Bits are all zero denotes a remote transmission problem. Bits all one denotes retransmit blank.

Auxiliary Station to Commander's Station	BITS
Word #1 (no remote tuning necessary)	
Not used	5-7
Update	4
CT	3
R/T Select	1-2
Identifier = 1	0
Word #2 (needs remote tuning)	
Preset	5-7
RF Power	2-4
ECCM	1
Identifier = 0	0

microprocessor continues to process other information. When the command microprocessor receives a valid transmission from the aux microprocessor, one of two possible actions takes place. The first possibility is to receive word 1 in which case the auxiliary R/T select pointer is updated to point to the information to be sent in the next command to auxiliary station UART transmission. If the change bit is set, then COMSEC is updated for that R/T. The second possibility is receiving word 2 in which case the R/T is updated both in command memory and through UART transmission to the R/T.

Response time for remote tuning is limited by speed of serial interface to the radios. All processing of other information stops during the remote tuning of an R/T. This degrades control response as well as response to PTT. This degradation in control response will only be seen when both command and auxiliary stations simultaneously request an R/T status change. Worst case PTT delay (when radios are not being tuned remotely) is 13.0 ms and is due to the commander-auxiliary interface.

Estimated program size is 900 bytes of ROM. This estimate is high because it was based on using the RCA CDP1802 with no RAM. Only internal registers to the CPU were used for calculations. Since an RCA CDP1804 does have a small amount of RAM on the chip, the program size will be considerably smaller. The 1804 will also make I/O less cumbersome.

Commander's Station Connector Considerations and Alternatives

The Commander's station interfaces with up to ten other boxes (i.e., radio, crew stations, etc.). These interfaces represent about 110 wires that could connect to the command station. In addition to the wire numbers, it would be advantageous to leave one side of the commander's station free of connections so installation would take a minimum amount of rework in retrofit situations.

There are four basic approaches to the interconnect wiring:

1. Point-to-point wiring
2. Multi-termination cable
3. Junction boxes in cable
4. Multiplexing to reduce wire numbers.

Point-to-point wiring has a connector for each place the wires are routed. This type of wiring has the following advantages: (1) Easy to maintain the wiring system, (2) increased reliability in that if one system fails because of wiring, it has no effect on any other system. The disadvantages are: (1) Too many connectors in the commander's box results in operator cable intanglement and potential for wrong connection, (2) cost increases since internal wiring complexity increases as the number of connectors increases.

Figure 3-8 depicts a typical connector configuration showing locations and sizes of connectors around the commander's control box with this type of wiring.

Multi-termination cable offers the ability to consolidate many little connectors around the commander's box into a few large connectors. The cabling would be constructed in such a manner that it would branch to the various points around the vehicle. This type configuration offers the following advantages:

1. Reduced number of connectors which increases the system reliability.
2. Reduced costs in assembly and in purchased part cost.

The basic disadvantages are:

1. Maintainability of the branching cable. A great deal of down time would be required to service a cable of this type.
2. Interchangeability of the system components could be a problem if the particular cable in the vehicle did not include provisions for every option.

These problems could be reduced by using protective conduit that would allow wires to pass through it. Connectors and wiring could be maintained without ever removing the complete assembly from the vehicle. This type of system would take up more space than a plain wire cable which is currently used. The cost of the conduit would exceed the savings made by reducing the amount of the connectors. Evaluations of life-cycle cost have not been made.

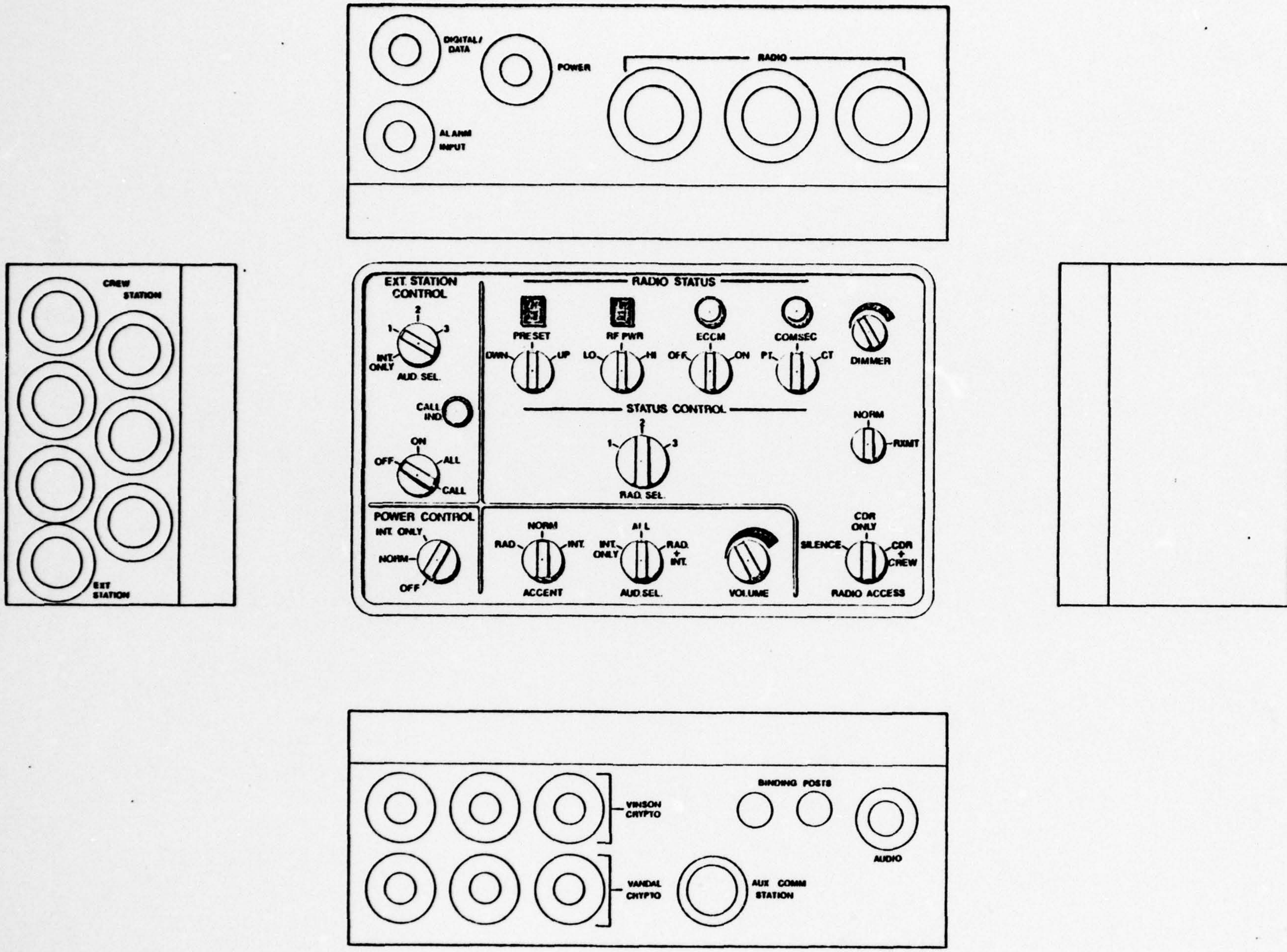


FIGURE 3-8: COMMANDER'S CONTROL BOX WITH DEDICATED CONNECTORS

Junction boxes in the cable offer the following advantages:

1. Consolidated connector at the commander's station to reduce connector clutter and problems in mounting the box.
2. Requires no complicated wiring harnesses.
3. The wiring harness can be maintained in sections that are easy to replace in the field.

The disadvantages of such a system would be:

1. Cost in additional connectors.
2. Reliability.
3. Additional space required (for boxes).

Each time one introduces a break in the transmission line, the probability of failure increases.

Figure 3-9 shows a typical connector configuration of the commander's box if multitermination or junction box wiring were used.

Multiplexing of the circuits would reduce the number of wires by making wires do multi-tasks. This would reduce the number of wires but the problem of how to cable to many unrelated boxes would still exist.

In the final selection of how the intercom system is cabled together, the following criteria must be addressed:

1. Maintainability
2. Space conservation
3. Cost
4. Reliability
5. Wiring adaptable to all vehicles

Through trips to various installations and conferences with Government personnel, ITT-A/OD has determined that maintainability is the key issue. To have good maintainability, one must use simple point-to-point cabling. This can be accomplished in a variety of ways (i.e., junction box, in-line cable connectors, etc.).

The final solution will be determined by various tradeoffs of the other four criteria for cable selection. This solution will be made at a later time when installation configuration is better defined.

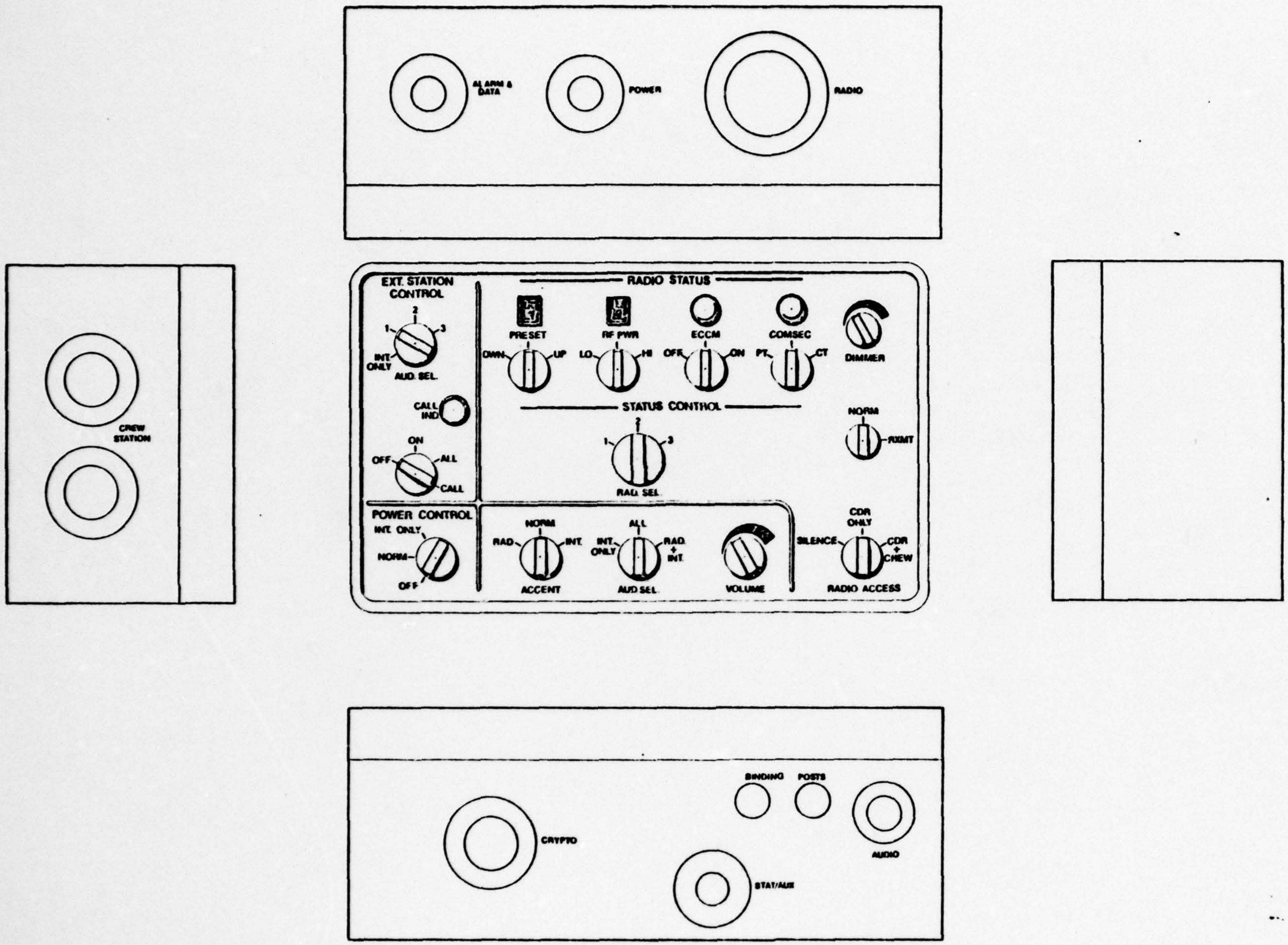


FIGURE 3-9: COMMANDER'S CONTROL BOX WITH OUTPUTS CONSOLIDATED TO A FEW PRIMARY CONNECTORS

Crew Station Front Panel and Connector Location

Crew station boxes should be approximately the same size as the present system. Probably a slightly reduced size could be expected. Figure 3-10 shows a typical configuration of a crew station. The front panel consists of three knobs: (1) radio select, which controls which radio the crew member receives or transmits over; (2) audio select, which allows the crew member to select what he hears; and (3) volume.

The station uses three connectors: (1) links the crew station to the commander's station; (2) an audio connector to connect the crew member's headset; and (3) a connector which allows the crew member to use remote keying. Other features which should be considered for the crew station are: (1) quarter inch diameter shafts for switches and pots; (2) mounting pattern identical to present units; (3) heavy mounting feet to bolt to.

CVSD Circuit Evaluation

There are currently two manufacturers of CVSD integrated circuits. These components are Motorola (MC-3418) and Harris (55532). The salient operating features of both devices were discussed in the Vehicular Intercommunications System Second Quarter Report (CORADCOM-77-0189-2).

The Harris HC-55532 CVSD device was received and tested in this quarter. The HC-55532 is designed for operation at 32 kBPS. Performance improves as the bit rate is increased. However, there is no external optimization and the CVSD circuit will not be at its optimum at the higher bit rates.

The Motorola MC-3418 was tested in the second quarter and the same active filters were used with the HC-55532 as the MC-3418. The test circuit, with filters for the HC-55532, is shown in Figure 3-11.

The HC-55532 was operated at the same 40 kHz clock rate as the MC-3418. Table 3-III compares the operation of the MC-3418 with the MC-55532.

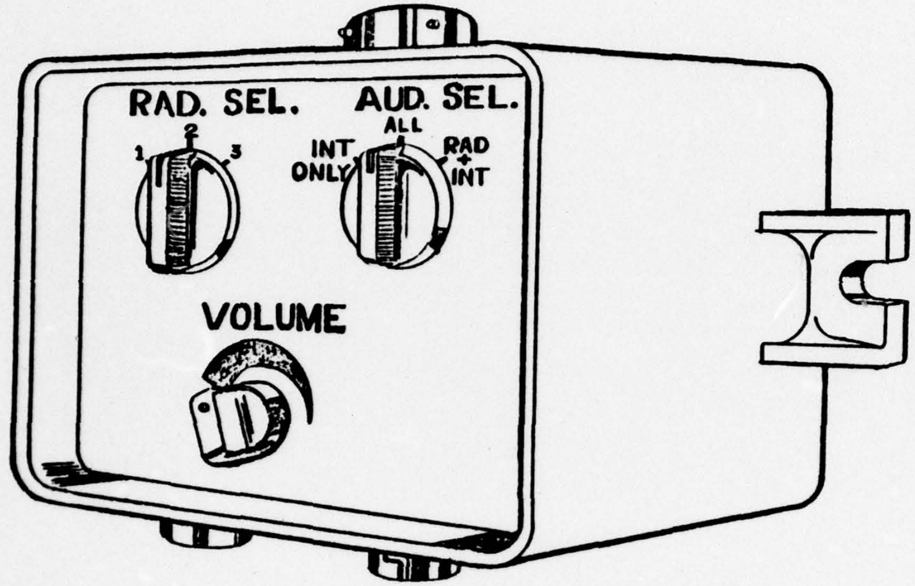


FIGURE 3-10: CREW STATION CONTROL BOX

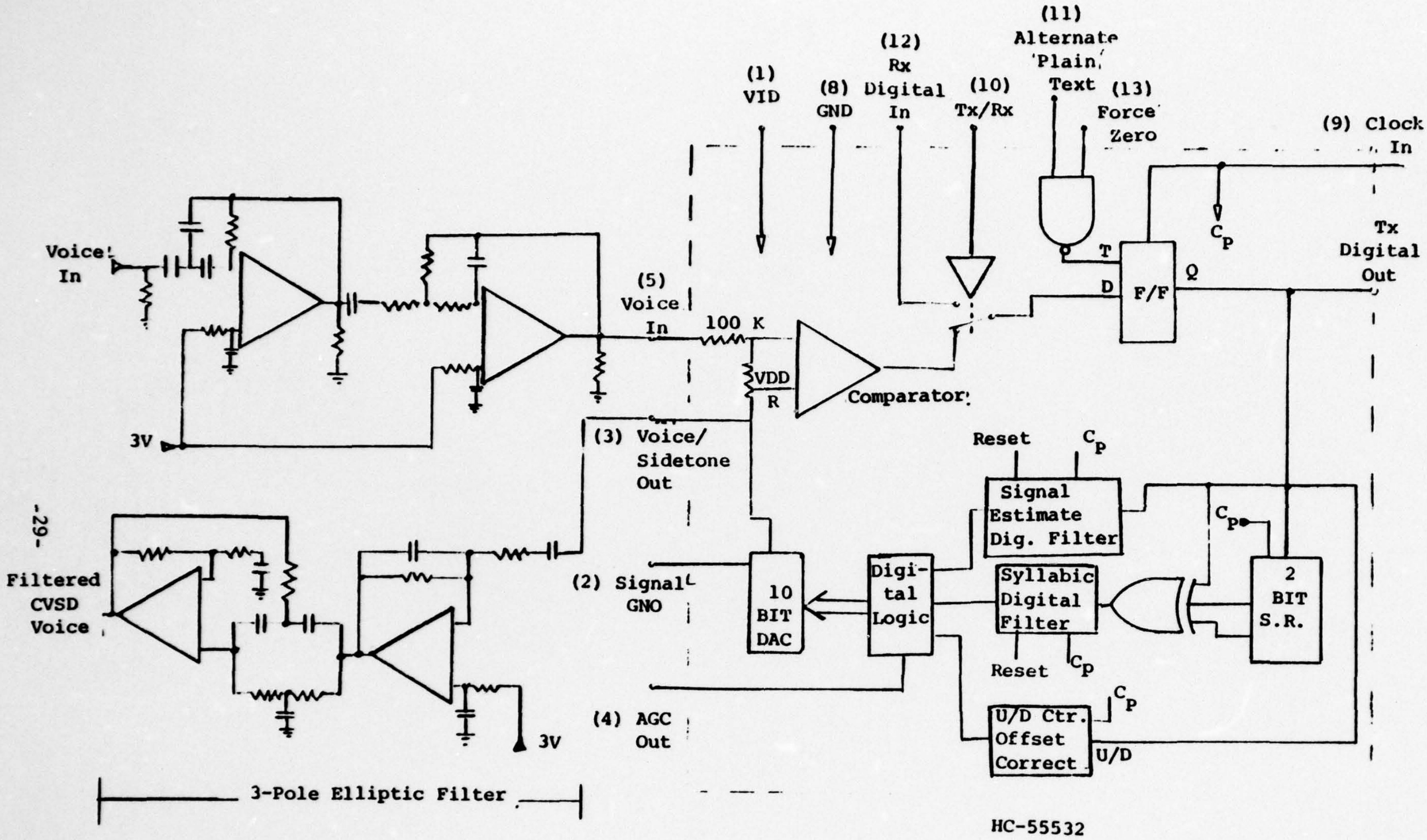


FIGURE 3-11: HARRIS CVSD TEST CIRCUIT

TABLE 3-III

MC-3418		HC-55532	
Input Level	SINAD	Input Level	SINAD
100 mV p-p	23 dB		
200 mV p-p	25 dB	300 mV p-p	15 dB
500 mV p-p	27 dB	500 mV p-p	21 dB
1V p-p	28 dB	1V p-p	25 dB
2V p-p	27 dB	1.4V p-p	23 dB

The data above indicates that because the HC-55532 cannot be optimized for the higher bit rates, its performance is reduced from that of the MC-3418.

Tape recorded speech was operated through both the HC-55532 and the MC-3418 and the speech quality of the MC-3418 was much better than that of the HC-55532.

Noise Testing of the TDM Breadboard

One of the major advantages of the digital data transmission is its inherent noise immunity. The objective of this test is to determine how severe the noise could be on the TDM line and be able to maintain communication. It was not known how much noise the TDM system could tolerate and still have commander-to-crew station integrity.

The breadboard which was discussed in the Vehicular Intercommunications System Second Quarter Report CORADCOM-77-0189-2 uses the MC-3418 operating at a 40k BIT rate and a TDM like operating at 240 kHz.

The TDM breadboard was built to model the intercom requirements. A block diagram is shown in Figure 3-12. The crew station can select one of three inputs to the commander's station, one of which can be a headset. The breadboard is also capable of duplex communication between the commander's station and the crew station. When the system is subjected to noise the audio signal and also the control information is affected. To maintain balanced lines, a transformer was constructed to inject noise into the line. Figure 3-13 shows the transformer and the breadboard line drivers, along with the characteristics of the transformer. It was assumed that the noise encountered in a track vehicle

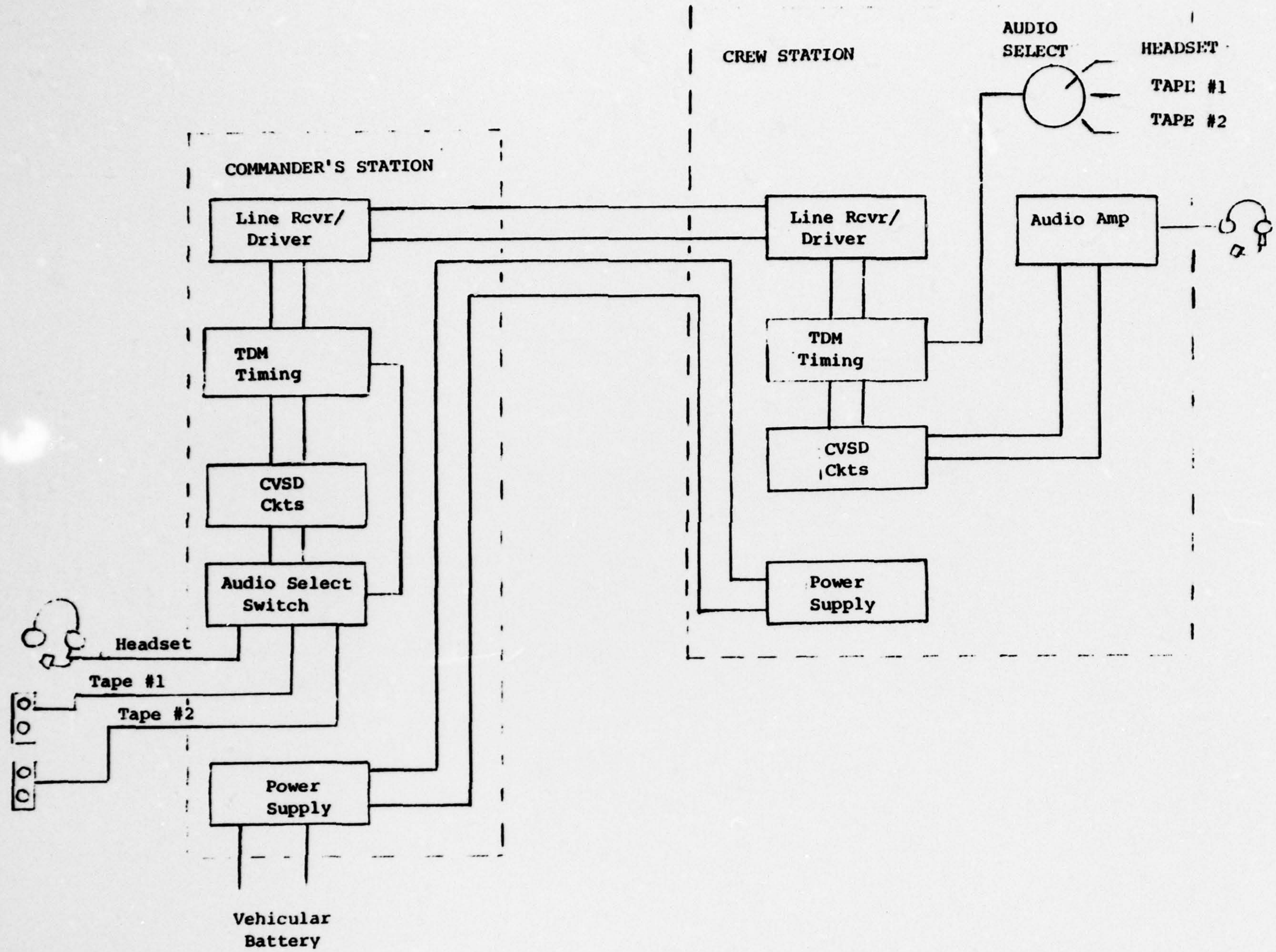
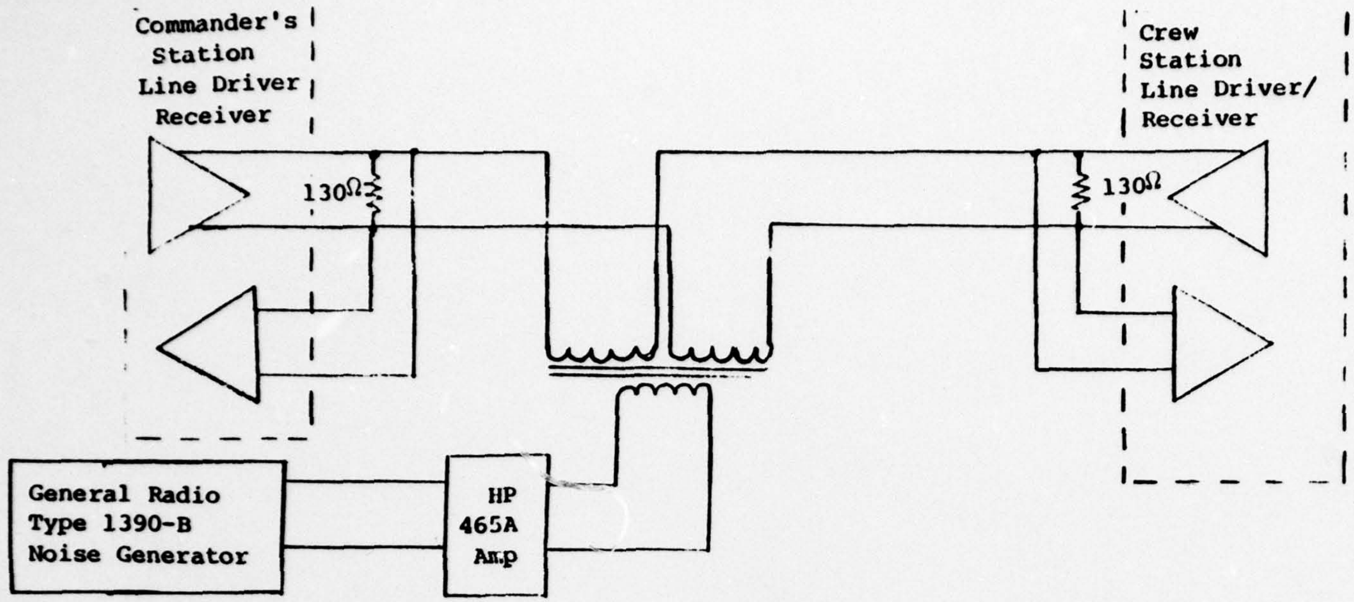
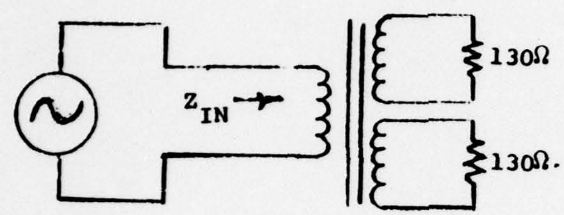


FIGURE 3-12: TDM BREADBOARD BLOCK DIAGRAM





TRANSFORMER FREQ. RESPONSE

30.5 kHz	REF
20.0 kHz	-.5 dB
500 kHz	-.29 dB
100 kHz	0 dB
220 kHz	-3 dB

TRANSFORMER INPUT IMPEDANCE

20 kHz	$Z_{IN} = 65\Omega$
100 kHz	$Z_{IN} = 65\Omega$
500 kHz	$Z_{IN} = 65\Omega$

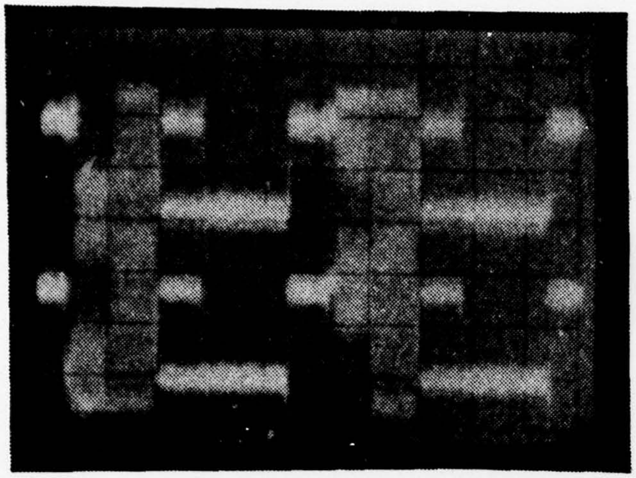
FIGURE 3-13: NOISE INSERTION TECHNIQUE FOR TDM BREADBOARD

would be fairly low in frequency <500 kHz. A "General Radio" random noise generator type 1390-B and an HP-465A amplifier were used to drive the transformer.

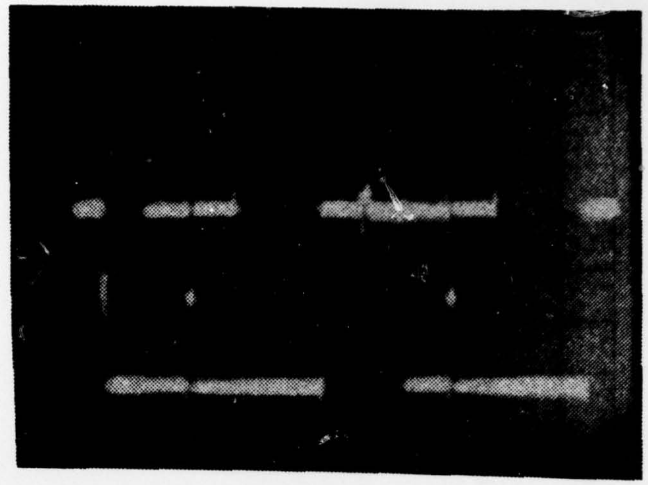
A 1 kHz tone was used from the command station to the crew station. With the system operating without noise, the crew station output had a SINAD measurement of 28 dB or 5 percent distortion. Figure 3-14 shows the amount of noise on the differential lines. Figures 3-14A, C and E show the noise on each differential line when referenced to ground. Figure 3-14B, D and F show the differential cancelling when the lines are referenced to one another. Figure 3-14A and 3-14B show the amount of noise required to degrade the system to 27 dB SINAD or 5.5 percent audio distortion. The high noise areas occur when the scope probe is placed on the side of the transformer which has the line transceiver in the receive mode.

Figure 3-14C and 3-14D show the amount of noise required to degrade SINAD 3 dB or (25 dB SINAD) or 6 percent audio distortion. Figure 3-14E and 3-14F show the amount of noise required to degrade the audio signal to 10 percent audio distortion. This results in a 22 dB SINAD.

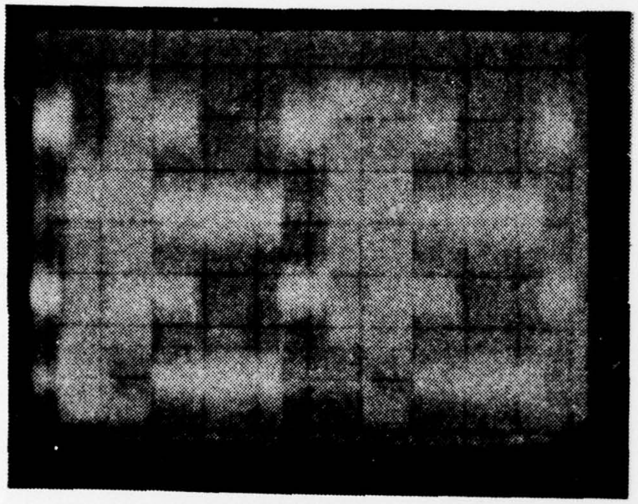
When operating with very extreme noise conditions, the system would not operate at less than 10 dB SINAD at the audio output. From this test, we found that the TDM system was very tolerant to noise on the transmission line, which will result in clear, reliable communication.



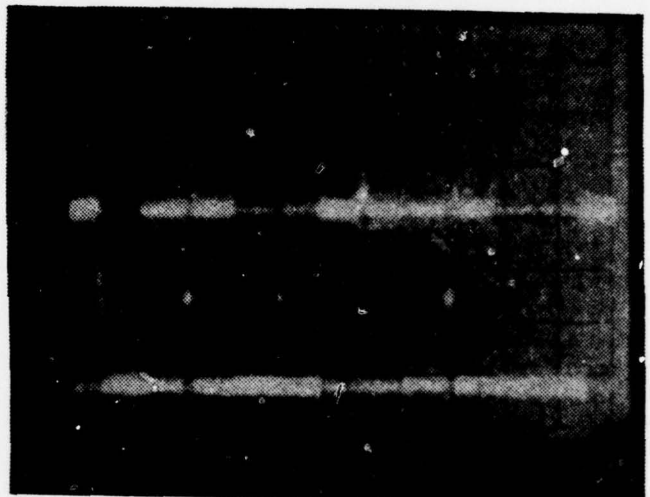
A



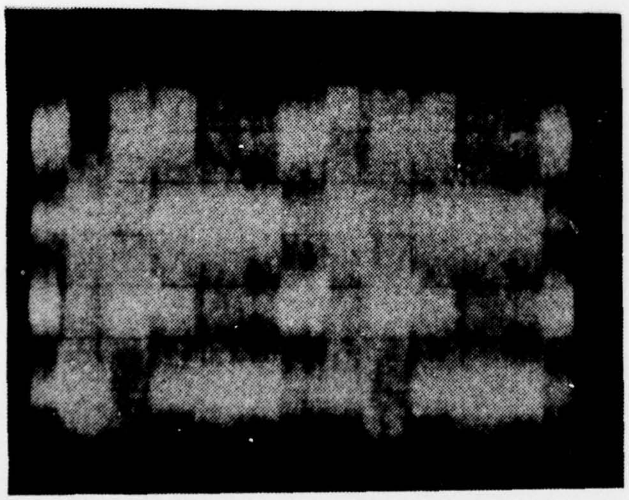
B



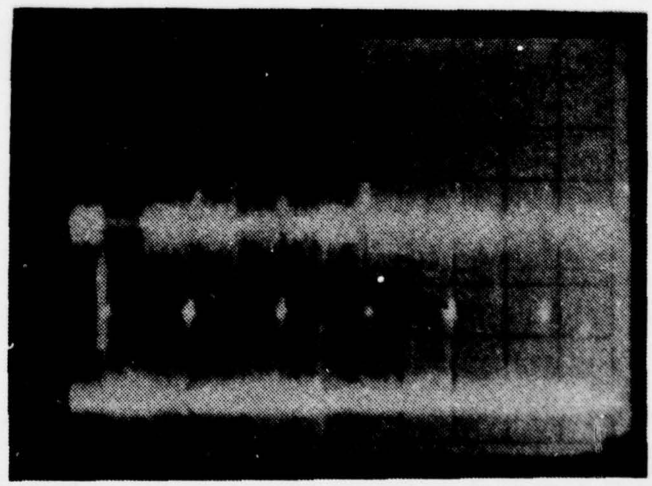
C



D



E



F

FIGURE 3-14: RESULTS OF NOISE TESTS